ABSTRACT

VOLUME 2: RESTORATION MONITORING FOR MARINE HABITATS

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INTRODUCTION:
The National Oceanic and Atmospheric Administration has joined with scientists and practitioners throughout the United States to develop a two-part volume that provides assistance and useful tools for developing and implementing scientific monitoring for coastal habitat restoration. This abstract presents an overview of various marine habitats to be discussed and a description of monitoring for restoration projects that was and is presently being used. The marine habitats that are addressed in this document include: hard bottom, oyster reefs, coral reefs, kelp and other large macroalgae, rocky shoreline, soft shoreline, seagrasses, marine/brackish marshes and mangrove swamps. In this document an annotated bibliography is also written to assist coastal engineers, scientists and non-scientists, in planning, designing and transplanting of coastal habitat vegetative species along with other measures of construction in order to restore these areas that underwent some impact causing degradation. The articles selected in this annotated bibliography were based on information that was readily available to us, techniques that have been and still are commonly being used and authors that have done continuous research on coastal habitats. The methods and techniques presented are just a few used for monitoring and restoring coastal habitats in both historic and recent research but by no means are a complete listing.

BACKGROUND INFORMATION
For the purpose of this document restoration monitoring is defined as the systematic collection and analysis of data that provides information useful for measuring project performance at a variety of scales (locally, regionally and nationally), determining when modification of efforts is necessary, and building long-term public support for habitat protection and restoration efforts. Coastal habitat monitoring helps understand complex ecological systems (Meeker et al. 1996) and is essential in documenting restoration performance and adapting project and program approaches. It also allows progress or early warning signs during restoration to be detected; and analyses of functioning and ecological health of the habitat (Galatowitsch et al., 1998).

Marine habitats have different structural and functional characteristics. A brief descriptions of some of the structural and functions for each marine habitat addressed in this document are as follows:

Hard bottom- The floor of a water body composed of solid, consolidated substrate, including reefs and banks. The solid floor provides an attachment surface for sessile organisms as well as a rough three-dimensional surface that encourages water mixing and nutrient cycling. Hard bottom also includes other habitats such as rocky intertidal shores, oyster and coral reefs. Some functions of hard bottom is that it provides refuge from predation, nursery grounds, breeding and feeding grounds as well as prevent shoreline erosion.

Coral reefs – These are diverse ecosystems, found in warm, clear, shallow waters of tropical oceans worldwide. They are composed of marine polyps that secrete a hard calcium carbonate skeleton continuously, which serves as a base or substrate for the colony thereby forming the reef. Some functions of hard bottom is that it provides nursery grounds, refuge from predation, breeding and feeding grounds as well as prevent shoreline erosion.

Oyster reefs – Dense, three-dimensional, highly structured communities of individual oysters growing on the shells of dead oysters. These communities occur across many acres of bay bottom and in intertidal and subtidal areas. These reefs may be divided into upward thrusting reefs, which normally occur in deeper estuarine waters, and fringing oyster reefs found in shallow embayments, lagoons, creeks, and shallow tributaries of estuaries. Some functions of hard bottom are that it provides nursery grounds, refuge from predation, breeding and feeding grounds as well as prevent shoreline erosion.

Kelp and large macroalgae - Relatively shallow (less then 50m deep) subtidal algal communities dominated by very large brown algae. Kelp and other large macroalgae grow on hard or consolidated substrates forming extensive three-dimensional structures that support numerous flora and fauna assemblages. Kelp bed depends on the availability of a hard substrate for attachment and on the availability of light for young autotrophs to grow (a function of water clarity). Some functions of kelp are sediment stabilization, influences hydrology and wave energy and refuge from predation.

Rocky shoreline - An extensive littoral habitat on wave-exposed coasts. Rocky shores are characterized by sharp environmental gradients from low rocky intertidal to upper intertidal. Rocky shores are composed of bedrock and cobble in tidal and non-tidal areas. Tidal rocky shorelines are exposed to pounding waves and the water level can vary substantially. For non-tidal rocky shorelines, the water level varies annually and seasonally. Rocky shorelines also provide several functions including biomass export, wave energy attenuation, spawning and nursery habitat for fish, invertebrate habitat, and bird and mammal feeding grounds.

Soft shoreline - Sandy beaches, dunes, and muddy shores. Sandy beaches are stretches of land covered by loose material (sand), exposed to and shaped by waves and wind (Brown et al. 1990).

These beaches and shorelines range from intertidal beaches to mudflats normally comprised of unconsolidated sediment. Dunes are essentially terrestrial systems with wind-driven sand transport and present a distinct physical and biological gradient from the sea landwards (Tinley 1985, McLachlan 1991). Mud and sand flats are usually associated with marine environments, especially where tides expose a large expanse of shore. The flats are exposed at extremely low tides and inundated at high tides with the water table at or near the surface of the substrate. The substrate of mud flats contains organic material and particles smaller in size than sand (EPA, 1980). Soft shoreline functions by providing breeding and feeding grounds for organisms.

Seagrasses - Submerged aquatic vegetation (SAV) are areas of flowering plants found in shallow, subtidal, or intertidal unconsolidated sediment. SAV are complex habitats that allow for high biological productivity. SAV habitats are typically a mixture of open water, rooted SAV, floating leaved plants, and occasionally short emergent vegetation.

Marine and brackish SAV, which are largely termed seagrasses, grow on soft sediments of sheltered shallow waters of estuaries, bays, lagoons, and lakes. Seagrass plant blades slow water currents, increasing sedimentation and nutrient uptake. SAV are physically stable have reduced mixing, and provide secure shelter.

Marine and brackish marshes - Composed of a mix of open water and vegetated areas, including short and tall salt marsh grasses and other plants. These are divided into zones based on elevation. Plant community composition is highly influenced by slight differences in elevation. Therefore, slope and elevation are defining aspects of the habitat. Some functions of marine/brackish marshes include feeding grounds, breeding grounds, biomass production and sediment deposition areas.

Mangrove swamps - Dominated by mangrove trees that live between the sea and the land in areas that are inundated by tides. Mangroves thrive along protected shores with fine-grained sediments where the mean temperature during the coldest month is greater than 20º C, which limits their northern distribution. Mangroves are salt-tolerant woody plants (Chapman 1976, Teas 1984). Some functions of mangroves include breeding and feeding grounds, protection from predation and stabilizes land elevation by sediment accretion.

MONITORING MEASURES USED: AN EXAMPLE HABITAT

There are consistent principles and approaches that are commonly used in successful monitoring for restoration in each habitat type. An example of a marine habitat functional characteristics and common parameters used when monitoring ***seagrasses*** is described here. Seagrasses grow on soft sediments of sheltered shallow waters of estuaries, bays, lagoons, and lakes. They are considered very productive plant communities. Their functions include:

Functional Characteristics

- Biomass production: Primary and secondary
- Improvement of water quality through increased sedimentation
- Erosion protection for adjacent shoreline areas
- Modified nutrient cycling: Nutrient and contaminant filtration
- Breeding and spawning ground
- Feeding grounds, resident and transient species
- Modification of water temperature and O_2 levels

The characteristics that define seagrass environments and how any changes within this habitat may be detected are listed below. An asterisk (*) denotes a measurement that, at the minimum, should be considered in monitoring restoration performance. Measures without an * may also be measured depending on specific restoration goals. These lists are not exhaustive but represent those elements most commonly used in restoration monitoring. These characteristics have been recommended for consideration by experts specializing in the restoration of this habitat.

Physical Characteristics

- Water level fluctuations: tidal, seasonal, and multiyear cycles *
- Salinity* (in tidal areas)
- Turbidity*
- Light levels (photosynthetically active radiation at canopy height and sediment surface)

- Temperature

Chemical Characteristics of the Water

- Nutrients (N:P)

Soil Measurements

- Texture
- Organic content
- Nutrients (N:P)

Vegetation Measurements

- Bottom coverage*
- Canopy characteristics* (leaf areal extent, structure, density, and biomass)
- Ratio of vegetated area to open water*
- Bed morphology and elevation
- Invasive species abundance and diversity*
- Shoot density
- Plant height
- Below ground biomass
- Associated epiphytes and macroalgae

Faunal Measurements

- Fish abundance and diversity
- Bird abundance and diversity
- Invertebrate abundance and diversity
- Microbial density and diversity

These are considered key elements for monitoring the success of seagrass restoration. Each parameter mentioned allows the structural characteristics and the function of the ecosystem to monitored and evaluated based on data collected. Understanding the structure and function of the habitat can help determine how a change physical or chemically within seagrass environments may affect the seagrass health. Therefore during the restoration process parameters selected for monitoring of restoration is important.

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